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Effects of Binaural Beat and Lavender Scent Inhalation on mood and Sleep Quality of Female Student-Athletes with Sleep Disorders

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ABSTRACT

Background: Sleep disorders in the Covid-19 pandemic and student life are among the issues of interest to researchers, especially when the student is an athlete. Therefore, the aim of this study was to evaluate the effect of binaural beat and lavender scent on mood and sleep quality in female student-athletes**. Methods**: In this quasi-experimental study, 48 female student-athletes with low sleep quality were selected by convenience sampling and randomly divided into 4 groups: binaural beat (BB); binaural beat + lavender (BL); binaural beat + placebo (BP) and control. Over a 21-day period, the BB group listened to the binaural sounds generated by beta, alpha, and delta waves at 6 Hz for 28 minutes at 225 Hz for the left ear and 231 Hz for the right ear. Lavender scent groups inhaled two drops of lavender scent with a cotton ball every night for 7 nights before sleeping and the placebo group consumed water instead. The Pittsburgh Sleep Quality Index (PSQI) and Social Mood Questionnaire were used to measure sleep quality and mood, respectively. Data were analyzed by descriptive statistics and analysis of covariance with Bonferroni post hoc test using SPSS24 software at the significance level of 0.05. **Results:** The results showed that the mean sleep quality of the BB and BL groups were significantly improved compared to the control group ($p \leq 0.05$). In addition, the mood status of the BB, BL, and BP groups were significantly improved compared to the control group ($p \leq 0.05$). **Conclusion**: Based on the findings, it seems that binaural beats with the inhaling the scent of lavender can improve sleep quality

1. Introduction

Sleep is one of the vital needs of human beings that is important in all age groups and plays an important role in physical and mental health (Khadije Irandoust & Taheri, 2016; Monleon, Hemmati Afif, Mahdavi, & Rezaei, 2018; Taheri, Irandost, Mirmoezzi, & Ramshini, 2019). Thus, the quality of night sleep can affect cognitive function and the level of concentration of people in daily activities (Taheri & Irandoust, 2020; Trabelsi et al., 2021). This seems to be especially important for athletes. Research evidence has shown that sleep deprivation can cause neurological, behavioral, and physiological changes (McMorris et al., 2006; Taheri & Modabberi, 2019). On the other hand, the relationship between athletic performance and emotions in athletes has been one of the topics that has always been considered by researchers (Irandoost, Taheri, & Seghatoleslami, 2015; Khadijah Irandoust et al., 2019). This becomes even more important when the individuals were faced with challenges of covid-19 pandemic (Abenza-Cano et al., 2020). Among the various emotions, mood is important as a structure that consists of six states of stress, depression, anger, confusion, empowerment and fatigue (Gaston & Prapavessis, 2013). The association between mood and sleep disorders has been well established in various studies (Crönlein, Langguth, Eichhammer, & Busch, 2016; Taheri & Valayi, 2019). Other consequences of sleep disorders include weight gain disorders, diabetes, hypertension, stroke, cardiovascular problems, depression, anxiety and other mood disorders, decreased nervous system function, and decreased endocrine and immune system functions (Chokroverty, 2010; Kabel et al., 2018; Palma, Urrestarazu, & Iriarte, 2013). In fact, it can be stated that insufficient sleep affects all aspects of life, including cognitive, physical, emotional and psychological function (Abdessalem et al., 2019; Monleon et al., 2018; Paryab, Taheri, Irandoust, & Mirmoezzi, 2020; Trabelsi et al., 2021).

While attending university, students experience several important changes, such as leaving home, increasing independence, changing peer groups, new social situations, retaining academic responsibilities, and increasing access to alcohol or drugs (Kirst, Mecredy, Borland, & Chaiton, 2014; Sharif & Sayyah, 2018; Vakili, Ehtram, & Sarbandi). Studies have shown that the prevalence of sleep disorders in the general population is between 15 and 42%,

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while among university students in non-Iranian studies, the rate has been 19.17 to 57.5% (Ghandour, El Sayed, & Martins, 2012; Lemma, Gelaye, Berhane, Worku, & Williams, 2012). Among Iranian students, the prevalence of sleep disorders in studies has been reported from 13.5% to 86.4% (Saleh Ahangar, 2014). The importance of sleep for student-athletes is important in two ways. One is that students with sleep disorders usually suffer from memory and attention problems during the day due to fatigue, which ultimately leads to poor academic performance (Curcio, Ferrara, & De Gennaro, 2006; Pagnin & de Queiroz, 2015). On the other hand, their athletic performance will be impaired due to sleep disorders (Samuels, 2008).

Due to the high importance of sleep, several treatments have been proposed to improve sleep quality or prevent and treat sleep disorders. The most common therapies used in this field are cognitive-behavioral therapy, medication, music therapy, and relaxation exercises (Nishinoue et al., 2012; Saeedi, Ashktorab, Saatchi, Zayeri, & Amir Ali Akbari, 2012). In this context, interest in the hypnotic effects of aromatherapy, a non-pharmacological treatment, has increased. Aromatherapy is a natural treatment that uses essential oils extracted from aromatic plants. These essential oils are believed to have medicinal effects and affect the brain, mind, and body (Inoue, Hayashi, & Craker, 2019). Among the active ingredients of this plant are linalool and linalyl acetate, which act as a sedative by acting on gamma-amino butyric acid receptors in the central nervous system (Farshbaf-Khalili, Kamalifard, & Namadian, 2018; Perry, Terry, Watson, & Ernst, 2012; Re et al., 2000). In a study, Tanida et al. performed experiments on rats and showed that the scent of lavender and the component linalool inhibits the activity of the sympathetic nervous system and increases the activity of the parasympathetic nervous system (Tanida, Niijima, Shen, Nakamura, & Nagai, 2006). Huberger et al. reported that linalool, a major component of lavender, has sedative effects in healthy adults (Heuberger, Redhammer, & Buchbauer, 2004). Another intervention that can have a positive effect on improving sleep quality is binaural beat, which is less expensive than drug interventions and acts non-invasively without any side effect (Lee, Song, Shin, & Lee, 2019). These studies provide some evidence for the potential sleep-enhancing effects of binaural beats (Garcia-Argibay, Santed, & Reales, 2019; Wahbeh, Calabrese, & Zwickey, 2007). However, it is important to note that more research is needed to fully understand the mechanisms and effectiveness of binaural beats on sleep.

The dichotic presentation of two almost equivalent pure tones with slightly different frequencies leads to virtual beat perception by the brain. In this phenomenon, the so-called binaural beat has a frequency equaling the difference of the frequencies of the two pure tones. The binaural beat can entrain neural activities to synchronize with the beat frequency and induce behavioral states related to the neural activities (Jirakittayakorn & Wongsawat, 2018). Considering the benefits of lavender scent and the effects of binaural beat, the question arises as to whether consuming lavender scent and listening to binaural beat would affect the mood and sleep quality of athlete students?

2. Materials and Methods

2.1. Participants

The study participants were all female student athletes aged 18 to 26 years in Qazvin province universities who had low sleep quality.

Convenience sampling method was applied. First, the information was provided by announcements in social networks (such as Telegram, WhatsApp, email), by which 70 people voluntarily announced their readiness to participate in the research. After screening according to the inclusion criteria (low sleep quality ≤5 in the PSQI, not having illness during the experiment, BMI: 25-30; 18-30 years. 48 subjects were selected. All subjects were asked to sign the consent form. Subjects were randomly divided into four groups: BB (n = 12); BL (n = 12); BP (n = 12) and control group (n = 12). Exclusion criteria were: more than one absence in the study protocol; pregnancy; and lactation.

2.2. Apparatus and Task

All groups completed the mood and sleep questionnaires before and after intervention. The PSQI is a self-rated questionnaire which assesses sleep quality and disturbances over a 1-month time interval. The PSQI yields seven subscale scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep medication, and daytime dysfunction. Component scores range from 0 to 3 and are summed to obtain a global score, which ranges from 0 to 21. Higher scores suggest greater sleep disturbance and a global score more than 5 suggests a significant disturbance (Taheri et al., 2019; Taheri & Valayi, 2019). SMQ as a self-report type, consists of 20 items. It consists of three main subscales including sociability (4 questions); physical activity (4 questions) and anxiety level (12 questions). Scoring system is based on a five-point Likert scale (e.g., strongly disagree = 1 and strongly agree = 5). Total scores of 20 and 40 are considered as poor; 40-60: moderate; and above 60: very good (Rieffe, Oosterveld, & Terwogt, 2006).

2.3. Procedures

The protocol was performed simultaneously in four groups. The subjects completed their demographic information before beginning of the study, and their sleep quality and mood were assessed by completing the Pittsburgh Sleep Questionnaire (PSQI) and Social Mood Questionnaire (SMQ), respectively. The first group was intervened by in a 21-day period of binaural beat. Frequencies used in the package were produced by the hardware and server of binaural beat Builder and with brain waves (beta, alpha, theta, and delta) which started with a difference of 13 Hz and finally reached to 6 Hz, which provided 225 Hz for the left ear and 231 Hz for the right ear. The protocol lasted For 28 minutes with headphones during 21 nights before bedtime. The second group had binaural beat as mentioned, in addition to inhaling lavender scent before going to bed for seven-nights by which two drops of pure lavender on a pre-prepared cotton ball was inhaled. The third group had binaural beat with taking placebo for 7 nights, using 2 drops of water on a cotton ball, which they were told as lavender. The fourth group was not given a protocol to perform. This research has been approved local ethics committee of Imam Khomeini International University (ref no: 17628).

2.4. Data Analysis

Analysis of Covariance (ANCOVA) and Bonferroni post Hoc Test were used to compare between-group results, at the significance level of P≤0.05.

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3. Results

As it can be seen in **Table 1**, the general information of the subjects are provided.

Table 1.
Descriptive statistics on personal characteristics standard deviation ± mean

Group variable	BB	BL	BP	Control
Age (yr)	23.51 ± 2.11	24.2 ± 1.1	23.08 ± 1.15	23.6 ± 2.4
Weight(kg)	50.55 ± 4.75	57.0 ± 3.7	56.8 ± 3.8	57.1 ± 3
Height(cm)	161.5 ± 5.1	162.8 ± 6.7	163.1 ± 6.3	161.9 ± 5.09
BMI(Kg/m^2)	21.2 ± 1.09	21.5 ± 0.8	21.35 ± 0.99	21.7 ± 0.75

As can be seen in **Table 2**, there was a significant difference between the groups in overall score of sleep quality. A Pair comparison with Bonferroni test suggested that there was a significant differences between intervention and control group as well as between BB and BL groups (P≤0.05). As can be seen in **Figure 1**, the mean sleep quality in the BB and BL group was significantly different from the control group (p <0.05), with a greater improvement for BL.

Also, there was a significant difference between the groups in mood status **(Table 3)**. A Pair comparison with Bonferroni test suggested that there was a significant difference between intervention and control group as well as between BB and BP; BB and control; BL and CONTROL; BP and CONTROL groups (P≤0.05) (**Figure 2**).

Table 2.
Results of analysis of covariance for the overall score of sleep quality

Subscales	Source	The sum of squares	df	Average squares	F	Significance	Eta coefficient	Power
sleep quality	Pre-test	66.07	1	66.07	57.54	0.000	0.57	99.54
	group	162.48	3	54.16	41.17	0.000	0.77	98.50
	Error	49.37	43	1.15	-	-	-	-

Table 3.
Results of analysis of covariance for overall mood score

Subscales	Source	The sum of squares	df	Average squares	F	Significance	Eta coefficient	Power
mood	Pre-test	662.58	1	662.58	149.46	<0.001	0.85	99.55
	group	54.43	3	18.14	5.31	0.003	0.72	99.09
	Error	146.99	43	3.42	-	-	-	-

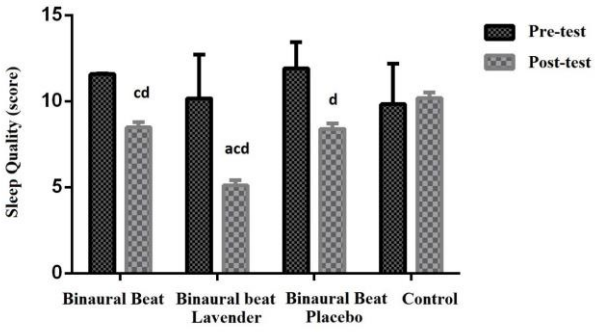

Figure1. *Sleep Quality of the groups*

a Significant difference with the BB at the level of p≤0.05
b Significant difference with BL at the level of p≤0.05
c Significant difference with BP at the level of p≤0.05
d Significant difference with the control group at the level of p≤0.05

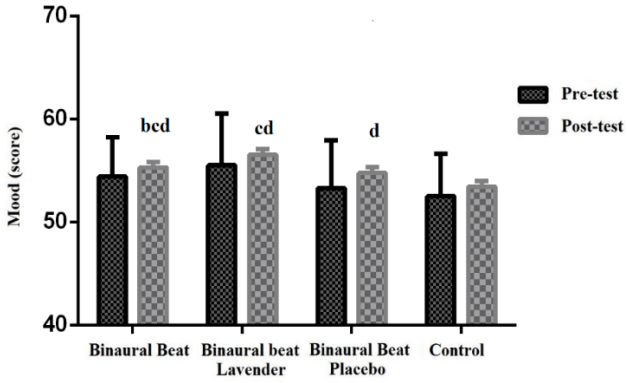

Figure2. *Mood Status of the Groups*

b Significant difference with BL at the level of p≤0.05
c Significant difference with BP at the level of p≤0.05
d Significant difference with the control group at the level of p≤0.05

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4. Discussion and conclusion

Given the importance of sleep on physical and mental health, in this study, we sought to see whether sleep quality and mood status of athlete's students with sleep disorders were affected by Binaural Beat and Lavender Scent inhalation. As the results showed, the use of binaural beat and scent of lavender created a significant improvement in sleep quality of female student-athletes, and this improvement was more tangible when both factors were used together. On the other hand, it was shown that both Binaural Beat and Lavender Scent variables had a significant effect on mood, while their synergistic effect was greater. It is important to note that the components of sleep and mood were closely correlated with each other. The characteristics of both factors were influenced by the independent variables of this study.it seems that the use of aromatherapy with lavender as well as Binaural Beat can play an important role in improving the quality of students' sleep, which not only can improve their sports performance, but also affect their academic performance. Based on evidences, the pattern of brain waves in people with sleep disorders is different from healthy people (Baker, 1985; Chauhan & Preetam, 2016).

The results of the present study showed that a 21-day period of binaury beat improved the sleep quality of female student-athletes. This result is consistent with the previous study that demonstrated the beneficial effect of binaural beat on sleep behavior (250 Hz of Beta wave was delivered to the right ear and 256 to the left ear) (Jirakittayakorn & Wongsawat, 2018). Our result is also consistent with the study of Cho et.al. who showed the positive effect of aromatherapy with lavender on anxiety and depression of hemodialysis patients (Cho, Min, Hur, & Lee, 2013). Complementary therapies are very popular today. One of these cases is the therapeutic use of herbs. Research has shown that many patients with mental health problems can benefit from the beneficial effects of herbs to overcome their physical and somatic problems (Wong, Lim, Luo, & Wong, 2009). The effects of lavender can be justified by the number of active ingredients available and their effects on some neurotransmitters involved in depression (Farshbaf-Khalili et al., 2018). In various studies, it has been shown that this plant has an effect on Gamma-aminobutyric acid (GABA) which improves mood problems. On the other hand, there are flavonoid compounds that affect benzodiazepine receptors (Medina et al., 1997). The rapid presence of some other active substances, such as Linalool and linalyl may contribute to affect parts of the central nervous system (de Sousa, 2012; Ren et al., 2019). Another explanation would be attributed to physiological effects of Lavender on some nervous structures (e.g., limbic system and hypothalamus) and also the ventromedial nucleus of the hypothalamus that that is highly related to mood swings (Cook & Lynch, 2008).

The hypothalamus is a major part of brain that controls the limbic system. It is believed that scent of lavender exert their psychological effects through its effect on the limbic system, in particular, the amygdala and hippocampus (Roiser, Elliott, & Sahakian, 2012). Interestingly, this pathway is also effective in regulating the sleep-wake cycle, so the effect of lavender on both mood and sleep quality factors can stem from this (Sanford, Suchecki, & Meerlo, 2014). It should be noted that the mechanism at the cellular level is not well proven. However, several studies have suggested that this plant has a similar function to benzodiazepines and increases gamma (gamma aminobutyric acid) in the amygdala (de Sousa, 2012; Perry et al., 2012). However, this research also has limitations. The small number of participants and the impossibility of evaluating brain waves were the main limitations of this work that are suggested for further research. Lack of strict control over the diet was another limitation that should be considered.In general, the results of this study showed that aromatherapy with the use of lavender along with the use of binaural eat would have positive effects on the mood and sleep quality of student athletes, which is due to the state anxiety of students due to their academic carriers and also sport.

Authors' contributions

Conception and design of the study: KH.I, F.A; Data collection: F.A; Data analysis and/or interpretation: F.A, M.T; Drafting of manuscript and/or critical revision: F.A, M.T; Approval of final version of manuscript: KH.I, M.T.

Conflict of interests

The Authors declare that there is no conflict of interest.

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